Marsh, Daniel.

Report on the introduction of a supply of pure water into the city of Rochester, 1860.

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REPORT

ON THE INTRODUCTION OF A

SUPPLY OF PURE WATER

INTO THE

CITY OF ROCHESTER,

MADE TO THE

MAYOR AND COMMON COUNCIL,

SEPTEMBER, 1860.

BY DANIEL MARSH,

CIVIL ENGINEER.

ROCHESTER:
STEAM PRESS OF C. D. TRACY & CO., EVENING EXPRESS OFFICE.
1860.

To the Honorable

The Mayor and Common Council

Of the City of Rochester:

GENTLEMEN:—In compliance with a Resolution of your Honorable Board, passed March 20, 1860, I have made a Survey and Estimate of a system of Water Works for the City, and herewith respectfully submit for your consideration, a Report of the proposed plan, with estimates of cost, and a map of the contemplated route.

DANIEL MARSH.

Rochester, N. Y., August, 1860.

REPORT,

On the Introduction of an abundant Supply of pure and wholesome Water into the City of Rochester.

Many considerations might be presented to show the importance of furnishing this city, from some one of the numerous sources situated beyond its limits, with an adequate supply of that element so essential to the business, safety, health and comfort of its population. Yet the necessity of obtaining this great and desirable boon for our citizens, is now perhaps so generally conceded, that it will not be expedient in this place to dwell upon the many obvious and imperative reasons why this enterprise should be undertaken, and we may proceed at once to state some of the leading characteristics of the Water Works in other cities, and also some of the particular local facilities and disadvantages attending the accomplishment of a similar work for Rochester.

The following Circular Letter has been recently addressed to the Presidents or Superintendents of all the Water Companies, or Water Boards in the country, and very satisfactory answers have been returned, either by definite replies to the interrogatories in the circular, or by sending their printed annual reports.

To the President and Directors of the Water Works Company or the Superintendent of Water Works, in ....

The construction, at an early day, of a system of Water Works for this city, being in contemplation by our citizens, any infor mation on the subject which you may be able to afford us, wil be duly and thankfully appreciated.

Allow us to request, at your earliest convenience, answers t the inquiries embraced in the accompanying abstract.

Please fill the blanks, so far as practicable, and return th sheet, addressed to "Daniel Marsh, Engineer, Rochester, Monro County, N. Y."

Will you also favor us with copies of your printed Wate Rates, Bills, Regulations, &c., and of your latest Reports?

S. W. D. MOORE,
Mayor of Rochester
C. J. HAYDEN,
President Rochester Water Works Company
H. D. SCRANTOM,
Mayor of Rochester
DANIEL MARSH,
Enginee

Please fill up the blanks opposite the following items of infor mation, relative to Water Works, in ....

When was the construction commenced?
When was the construction completed?
What was the original cost?
What was the estimated cost?
What is the extent of main pipe?
What is the extent of distributing pipe?
What is the size of main pipe?
What is the size of smallest street pipe?
Of what material is the pipe composed?
What the extent of cast iron pipe?
Do. wrought iron pipe?
Do. lead pipe?
Do. wood pipe?
Comparative merits of each?

What is the daily supply of water furnished?
Source whence the water is obtained?
Is the water introduced by Water Power?
Steam Power?
or Gravity?
What is the population of your place?
Assessed valuation of Real Estate?
What are your annual expenses?
What is your annual income?
Vertical head of water over the street pipe?
Efficiency of Fire Hydrants?
Are Fire Engines needed and used?
Extent of recent losses by fire?
Comparative rates of Insurance before and since completion of Works?
Comparative frequency of Fires since completion of Works?
Do you use any lead service pipe?
With what effect upon the health of water-takers?

In the progress of this survey, the expediency of embracing a large storing Reservoir, in the plan of Water Works for Rochester, became an important question. Such reservoirs have recently been constructed in several instances, and by retaining the surplus water of that period of the year when there is abundance, in store, to be distributed during the period of drought and deficiency, afford a plentiful supply from sources which do not during the dry season alone, furnish half the required quantity. For the last few years there has been frequent complaint of the quality of the water drawn in summer from the reservoirs at some of the most important Water Works in the country; it was believed therefore, that the most sure and satisfactory course, was to ascertain by personal observation and inquiry as to the success attending the experiment of large Reservoirs.

To obtain this information, the necessary tour and examination were made late in June last.

It may facilitate the inquiry as to the feasibility and expediency of any plan of works which may be proposed for our consideration, to give some account of the successful efforts of other cities in obtaining a supply of water, and to present the whole subject of Water Works for Rochester, in the following order:

Principal Water Works in other cities.
General Table of Analysis.
Tabular Statement of Water Statistics.
Different Modes of conveying Water into Cities.
Quantity of Water required.
Distributing Reservoirs.
Sources of Supply for Rochester.
Quality of these Waters.
Storing and Subsiding Reservoirs.
Conductors of Water.
System of Distribution for Rochester.
Estimates of Cost.
Probable Income.

Principal Water Works in Other Cities.

Philadelphia.—The first works of much importance which were constructed in this country to supply the inhabitants of a populous district with water from beyond the inhabited territory, were commenced in this city about 1799. At an early day, Benjamin Franklin publicly called attention to the fact that the ravages of contagious disease, and particularly the Yellow Fever, which had but recently visited the city, were doubtless greatly increased by the limited and impure supply of water, and he pointed out the necessity and practicability of procuring an abundant supply from beyond the city. He provided in his will to aid in bringing the water of the Wissahickon Creek into the town. In 1797, this suggestion was discussed in the City Council, and in 1801, the Center Square Works were completed, and began supplying the city, by means of steam power, with water from the Schuylkill River. These works, which cost the City about $657,000, are now entirely out of use.

Of the works which were constructed at Fairmount, those which raised the water from the Schuylkill by steam power, were completed in 1815, and those which make use of water power for that purpose, were completed in 1823. The latter only are in use at the present time. These works consist of 8 Breast Wheels, and one Turbine, which with suitable pumping machinery, are together capable of elevating 721,219 gallons of water per hour, into four combined reservoirs, which are situated on adjacent elevated ground 96 feet above the Schuylkill. The whole capacity of the Fairmount Reservoirs is 46,413,867 gallons. These works are to be enlarged this season by the addition of two Turbine Wheels.

The Schuylkill Works were erected in 1844, and consist of 4 steam engines and pumps, and 10 boilers. The water is raised 115 feet into a Reservoir, which will contain 9,800,000 gallons. All the pumps are connected with one stand pipe, 137 feet high.

The Delaware Works are on the Delaware River. They have 2 engines and 2 Reservoirs capable of containing 9,284,000 gallons. The quality of the water taken from the Delaware River, is not so satisfactory, as that of the Schuylkill. The Water Department have recommended to the City Council the abandonment of the Delaware Works, and the procuring of the supply of water for the entire City, from the Schuylkill River.

The Twenty-Fourth Ward Works are on the West side of the Schuylkill River. Two Cornish engines force the water 2,000 feet into a stand pipe 230 feet above the River. The distribution is made directly from street mains connected with the stand pipe, without a Distributing Reservoir.

The total cost, the annual income and expenses, and other interesting statistics of these works, as well as of all others from which returns could be obtained, will be stated in a table to be annexed to these descriptions.

New York.—The Croton Water Works, which are the most extensive and costly in this country, were completed and first supplied the city with the water of Croton River, in 1842. By a dam 40 feet high, across the stream, a Reservoir or Lake, of 400 acres is formed, capable of containing 400,000,000 gallons of water.

From this source, the water is conducted through an aqueduct of stone, lined with brick, a distance of 38 miles, to a Receiving Reservoir in the City, of 31 acres, and thence by iron pipe, to the Distributing Reservoir of 4 acres, at Fortieth Street. The water is conveyed across Harlem River in iron pipe, about 1377 feet long, depressed about 11 feet below the grade line of the Aqueduct, and supported on a high bridge, consisting of 15 arches. This work is 150 feet high above the foundations, and 21 feet wide upon the top. The actual supply of water for the City of New York, and the capacity of the works was limited at the High Bridge, to 30,000,000 gallons per day, by the size of the main pipe at this place—there being two pipes of 3 feet diameter each.* A new pipe of boiler iron, of 7 feet diameter, is to be laid across the Bridge this season. Across the Manhattan Valley, the water is conveyed in pipe, at a depression in the lowest part below the grade of the aqueduct, of 102 feet.

*See Note B.

From the Distributing Reservoir at Fortieth Street, the water is conveyed through the city by 263 miles of cast iron pipe, of various sizes. The whole extent of Reservoirs in New York, is 35 acres, and their capacity, 170,000,000 gallons. To these, it is proposed to add a Reservoir of large extent, near the new Park, the construction of which is already considerably advanced.

It is generally understood that the original estimated cost of this work was $7,000,000, that when the water was introduced into the city in 1842, the expenditure amounted to from $13 to $14,000,000. The cost of the whole work, exclusive of the pipes, in the city, below the Distributing Reservoir, was $9,000,000. The late President of the Board, Nicholas Dean, stated publicly in 1853, that the total cost at that time amounted to $21,000,000, and at an interview recently with the Chief Engineer, I was informed that the total cost at the present time amounted to $23,000,000.

Boston.—This city obtains its supply from Long Pond, or Cochituate Lake, from which it is conducted in a brick conduit, 15 miles long, to Brookline Reservoir, situated about 5 miles westerly from Boston. This Reservoir is about 22 acres in extent, and will contain 89,909,000 gallons. Thence the water is conveyed by iron pipe, to Reservoirs on Beacon Hill, and also upon elevated ground in both East and South Boston. The capacity of these works to furnish water to the City, was much increased during the last season, by laying down an additional and large-sized main from the Brookline Reservoir to Boston. The Reservoir on Beacon Hill is a substantial and beautiful structure of granite, supported by massive stone arches—those in East and South Boston consist of earth embankments. The total capacity of these Reservoirs is 15,779,030 gallons. Cochituate Lake has an area of 660 acres, and can supply more than 30,000,000 gallons per day, for the year. Two compensating Reservoirs have been constructed, to restore to the outlet of this Lake a quantity of water equivalent to the original flow from the Lake, for the purpose of maintaining the rights of the owners of hydraulic power below. In respect to the quality of the water introduced, and to the economy with which this supply is made, these Works may compare very favorably with those of any other large city in the country. The comparative quality of the water, and cost to water takers, are exhibited in the table of general analysis, and in that of cost of Water Works. Two evils attend these advantages,—that of the corrosion of the water pipes on their interior surface, and that of the unpleasant smell and unwholesome character of the water supplied during a short period of the last two or three years. For the first, no effectual remedy has been found, but for the last, I have little doubt, from personal examination, and from the opinions and tests of our most experienced chemists, that an effectual remedy will be found.

Pittsburg—Is supplied with water from the Allegany River by steam power. There are two Distributing Reservoirs, one at an elevation of 160 feet above the River, and the other of 396. To the first Reservoir, the water is raised by two engines, and to the upper Reservoir the water is raised from the lower one by two engines also. The pumping main between the Reservoirs is used as a distributing main, the water being served directly to the inhabitants by the force of the pumps, which is believed to have an unfavorable effect upon the water, and causes much complaint. The Reservoirs are formed of earth embankments lined with brick. The cost of these works was £700,000 in 1853, and those of Allegany City cost $331,442. This suburb, like Pittsburg itself, obtains its supply from the Allegany River by two steam engines, which force the water 206 feet to the Reservoir.

Brooklyn—has just completed an extensive system of Water Works, and is receiving a supply of the purest water from a series of springs and small streams on the south shore of Long Island. A storing Reservoir has been formed at a very considerable expense, by removing from the natural basins in which those streams originate all perishable material and deposit which would be unfavorable to the purity of the water, and from such reservoirs the water is conducted in a conduit of brick to the pump well. From this point the water is forced through a large main three-fifths of a mile to a Reservoir, elevated 170 feet above tide. This pumping engine is a double acting cylinder engine, and one of the largest in the world, capable of raising to the Reservoir, 10,000,000 gallons of water in 24 hours. A duplicate of this engine is soon to be added to the works.

The Ridgewood Reservoir covers a surface of 32 acres, and is capable of containing 170,000,000 gallons. It is the largest artificial Reservoir, and constructed on the best site for such a work in the United States. From this receptacle, which is distant about 6 miles from the City Hall in Brooklyn, the water is conveyed by about 170 miles of pipe, of various sizes throughout the city, except a small territory around the sides of Prospect Hill. A small engine is to be erected, to raise water from the mains, near the hill to a reservoir on its summit, from which any part of the city can be supplied.

Within 20 miles from the City Hall in Brooklyn, 40,000,000 gallons of water per day can be collected on the south side of the Island, and within 23 miles on the north more than 20,000,000 gallons. This city can not, therefore, be without a bountiful supply of the purest water, until her population shall exceed *one million*.

Albany—obtains its supply of water from Patroon's Creek, upon which two reservoirs have been constructed; the largest and most distant being called Rensselaer Lake, and the other Watervliet Lake. From Rensselaer Lake the water is conveyed by a brick acqueduct, 4 miles long, to the Distributing Reservoir (Bleeker Reservoir,) and then to all the city above Pearl Street, by cast iron pipes. Those portions below this street, are supplied directly from the Watervliet or Tivoli Reservoir—the higher and the lower service being thus disconnected, except at times when a greater than the ordinary head is required to extinguish fires, and then the whole head from Bleeker Reservoir is put on to the pipe on the lower streets. The Watervliet Reservoir consists of two parts, a subsiding and a distributing reservoir, so arranged that the water of the Creek, when very turbid, is passed through waste gates, and not again received into the reservoir until restored to its usual purity. The extent of all these reservoirs is above 60 acres, and their capacity 230,000,000 gallons.

At the Bleeker Reservoir the water is drawn from near the surface, or the bottom of the Reservoir, as the quality of the water may at either point be most suitable for distribution.

Hartford—is supplied from the Connecticut River by steam power. The Reservoir is 118 feet above the surface of the river, and is formed of earth embankments raised to considerable height, with the inner slopes lined. These works have the usual arrangement of supply-pipe, pump well, and pumping engine. The latter is of a novel character, being a double acting force pump, and imparting a uniform and continuous movement to the column of water from the pump to the Reservoir. No stand pipe is required, and it is claimed that this engine performs a very high rate of duty, being 50,000,000 pounds of water raised one foot high with 100 pounds of coal. It is in contemplation to introduce an additional supply of water by gravity, to be distributed from a higher elevation than the present reservoir.

Jersey City—is furnished with water from the Passaic River, by steam power, the works having been completed in 1859, at a cost of $1,118,790. The supply of the City was commenced with a single Cornish engine, acting without a stand pipe—this usual appendage of the Cornish engine has been erected the past season with a good result, and it is proposed to duplicate the engine and pump. The water is conveyed 2,300 feet in pipe to the Receiving Reservoir, 157 feet above the River, and thence across the Hackensack marshes to the Distributing Reservoir on Bergen Hill, about 6 miles distant. The Reservoir will contain 30,000,000 gallons. The difference of level between these reservoirs is 25 feet, and the iron main 20 inches in diameter, delivers 2,000,000 gallons on Bergen Hill, in 24 hours.

Buffalo, *Cleveland*, *Detroit and Chicago*—are all supplied with water from the Lakes, or from the Rivers into which their waters are discharged. In all these places the works are quite imilar, the water being brought by an inlet pipe of considerable ength, to the pump well, and thence forced directly by one or nore large engines to a reservoir situated on the highest ground which could be found in the vicinity of those places, except that n Chicago no such elevation could be found; and its place is applied by an elevated tank. In Cleveland, such elevation is tained by an artificial embankment, at an expense of $80,000. At Buffalo, the water is conveyed from the River to the pump ell, by a tunnel excavated through the rock under the Erie anal. The Reservoirs at both Buffalo and Detroit are of too tle elevation for the purposes of a good distribution. Constant umping, at great expense, will always attend the supply of ese cities with water, but it could be obtained in no better way. he water of these Lakes appears from frequent analysis to contain very little foreign matter, except during the prevalance of a storm, when the water pumped to the Reservoir, and then distributed to the inhabitants of those cities, is turbid and ı pleasant.

Cincinnati, St. Lous, Louisville and New Orleans—obt water from the Ohio and Mississippi Rivers, by steam pow At Cincinnati and St. Louis the works are old, and inadequ to the full supply of those flourishing cities. From the want sufficient capacity in the Reservoir at Cincinnati, the water pumped from the River, and distributed to the people on t same day, causing serious complaint of the quality of the wa whenever the river is low. The works at Louisville are now the course of constrnction.

At *Troy, Utica, Syracuse, Cohoes* and *Geneva, N. Y.*, a *Springfield, Mass.*, Water Works which furnish those pla more or less liberally, have been some time in operation.

Baltimore, Richmond and *Savannah* are provided with Wa Works; and at *Washington, D. C.*, works on a liberal scale in progress, designed to supply to the Capital, the water of t Potomac River.

Recently, *Rockland*, Me.; *Cambridge, Plymouth* and *Pi field*, Mass.; *Bridgeport* and *New Britain*, Conn.; *Malo Watertown* and *Saratoga Springs*, N. Y.; *Paterson, Newa Trenton* and *Elizabeth*, N. J.; *Scranton* and *Harrisburgh*, I have constructed Water Works of a liberal character, capa of supplying those places very fully. Statistical informati relative to them may be found in the subjoined table.

At *Toronto, Montreal* and *Quebec*, in Canada, importa works have been constructed for the supply of those cities.

Table showing the quality of the Water used for the Supply of Various Cities, both in this country and in Europe.

City Supplied.	Source of Supply; or, name of Water Works.	Persons making or reporting the Analyses.	No. grains pr. gallon.
London	Thames.	Professor Brand.	28.
"	New River.	"	19.20
"	Average of total supply.	H. P. M. Burkinbine.	21.46
"	Well St. Paul's Church Yard,	Wm. J. McAlpine.	75.00
"	" Lambeth (shallow.)	"	100.10
Paris, ...	River Seine.	Baldwin & Stevenson.	12.74
"	Artesian Well.	Wm. J. McAlpine.	9.86
Lyons,.........	River Rhone.	Baldwin & Stevenson.	12.88
	Lake Geneva.	"	10.64
New York,...	Manhattan Well.	F. B. Tower.	125.00
"	Average of several wells.	"	58.00
"	Croton River at Dam.	"	4.99
"	Croton.	B. Silliman.	10.93
"	"	B. Silliman, Jr.	6,66
Philadelphia	Schuylkill River.	Booth and Garnett.	6.10
"	"	Baye.	4.42
"	"	B. Silliman.	5.50
"	"	F. B Tower.	4.08
Boston,........	Cochituate Lake.	Wm. J. McAlpine.	1.85
	do.	H. P. M. Burkinbine.	3.37
	do. 62 feet deep	Wm. J. McAlpine.	3.57
	do.	Dr. Jackson.	5.00
	Well Beacon Hill.	"	50.00
	Average three wells.	"	44.46
	Average of Croton Analyses.		7.26
	" Schuylkill "		5.02
	" Cochituate "		3.45
Brooklyn,...	Average several wells.	J. R. Chilton.	45.40
"	Long Island streams.	"	2.48
"	do. do. do. 2nd sample.	"	2.367
Albany, ...	Hudson River.	Dr. Emmons.	7.24
"	" "	"	6.32
"	Rensselaer Lake.	"	4.72
"	Well Capital Park.	"	65.52
"	Average several wells.	"	48.69
Cambridge, ..	Fresh Pond.	Baldwin & Stevenson.	6.32
Jersey City,..	Passaic River.	"	7.44
Troy,..........	Mohawk River.	"	7.88
"	Served by Water Works.	"	6.29
Hartford, ...	Connecticut River.	M. C. Weld.	2.618
Cincinnati ...	Ohio River.	J. M. Locke.	6.73
Detroit	Supply from River.	Prof. Douglass.	5.72
"	Wells.	"	116.46
Indianapolis,	Wells.	D. Marsh.	60.00
Montreal,....	Ottawa and St. Lawrence.	T. C. Keifer.	7.04
Quebec,........	St. Charles River.	H. P. M. Burkinbine.	8.10
Hamilton, ...	Grand River.	Sam'l. McElroy.	12.66
"	Burlington Bay.	"	8.44
Elmira, ...	Carr's Creek.	D. Marsh.	4.00

Table showing the Cost, the Annual Receipts and the principal Water Works

City Supplied.	Cost of Works.	Daily Supply. Gallons.	Ext'nt of pipe. miles.	Power used. Water and steam
Philadelphia,	$ 3,900,000	19,638,442	306½	
New York,	23,000,000	30,000,000+	263	Gravity.
Boston,	5,574,323	15,000,000	130	do.
Pittsburg,	700,000	4,075,755	26¾	Steam.
Brooklyn,	4,800,000	10,000,000	170	do.
Albany,	1,074,790	2,500,000+	46	Gravity.
Hartford,	427,587	785,338	26	Steam.
Jersey City,	973,326	2,000,000	28¾	do.
Buffalo,	530,000	3,000,000	32	do.
Cleveland,	550,000	1,000,000	22	do.
Detroit,	829,925	2,142,774	61	do.
Chicago,	1,014,146	3,000,000	72½	do.
Cincinnati,	1,359,500	4,618,567	76	do
New Orleans,	1,000,000	6,000,000	55	do.
Troy,	205,000			Gravity.
Utica,	75,000	800,000	10	do.
Rockland,	50,000		20	do.
Cambridge,	300,000	400,000	16	Steam.
Plymouth,	82,000	60,000	11	Gravity.
Bridgeport,	115,000	400,000	15	do.
New Britain,	50,000	300,000	10	do.
Malone,	12.000	30,000	5½	do.
Watertown,	50,000		9	water power.
Elizabethtown,	109,628	500,000	7	Steam.
Trenton,	117,000		10½	water power.
Scranton,	100,000	75,000	9¾	Steam
Washington,	5,000,000+	67,000,000		Gravity.
Rochester,		2,000,000	50	do.

See note B.

Expenses, the Capacity, and other characteristics of in the United States.

Annual expenses.	Annual Receipts.	Reservoir above str's.	No of Fire hydrants.	Capacity of Reservoir: gall's.	Number of Takers.	Rate per head;g'ls	Date of cons'n.
$79,389	$551,180	94–115ft.	2,680	655,000,000	64,125	50	1853
52,257	809,219	80–100		600,000,000		70	1842
29,088	316,290	10–125	1,363	106,000,000	23,276	72	1848
26,000	63,000	160				40	1829
		170		240,000,000		40	1860
8,000	80,517	100–140	251	230,000,000	4,600	36+	1852
7,771	26,000	30–110	138	8,000,000	3,933	40	1856
20,000	65,000	100				40	1854
19,000	50,000	88		13,000,000		36	1852
8,623	13,980	40–160	132		1,000	20+	1856
15,586	57,192	17–73	238	5,237,000	6,794	30	1853
35,372	102,709	50–90	283	493,000	8,231	23+	1854
51,303	184,837	10–100		5,000,000		40	1859
26,000	140,000	50				31	1838
5,000	21,941	70					1834
1,300	9,000	140				36	1849
1,500	5,000	80					1852
3,500	12,000	60				13	1858
500	3,700	95				14	1856
2,000	7,000	115	20	200,000,000		40	1853
		175	16	400,000,000			1859
250	1,500	145				6	1857
1,500	3,500	150–240	636	5,000,000	360		1853
1,600		30–60	50			50+	1858
		30–100					1856
		150				12	1858
		145					186
		70–180	200	60,000,000	5,500	40	

Table showing the Elevation of the points named above Lak Ontario, or above the Erie Canal in Rochester.

LOCALITIES.	Distance from Rochester—Miles.	Above Lake Ontario. Number of feet.
Top of Lower Falls,	2	98
Head of Buell Avenue,	2	208
Lake View,		279
Erie Canal in Rochester,		260
Above the Erie Canal in Rochester.		
Summit of Spring Street,		18
" Plymouth Avenue,		19
" St. Paul Street,		24
" Court Street,		26
" Gibbs and Main Streets,		30
" East Avenue,		28
" Buffalo and Genesee Streets,		24
Washington Square,		26
Brown "		
Franklin "		26
Fourth and South part of Fifth and Sixth Wards,		25
Seventh Ward,		2–20
Twelfth "		2–30
Eighth "		10–30
Third "		0–20
Second and North part of First,		Below
Ninth Ward,		"
North part of Fifth and Sixth Wards,		"
Genesee River at Main Street,		28 below
" " Clarissa Street,		5 "
Allen's Creek at Scottsville,	12	22½
Conesus outlet at Avon,	21	40
Honeoye Falls,	16	145
Honeoye outlet at Smithtown,	17	204
Honeoye and Hemlock outlets at Junction,	22½	284
Site of Reservoir near " "	23	295
Outlet Richmond Mills,	23⅔	326
Hemlock Lake,	28	388
Honeoye Lake,	28	290
Canadice Lake,	28	500
Wadsworth's hill, Eighth Ward,	1½	50
Ridge west of Mount Hope,	2	60
Do. east " "		113
Hill in east part of Henrietta,	6	125
Mendon Ponds,	8	131

Modes of Conveying Water into Cities.

Residing in a city which is surrounded by streams and bodies of water, any one of which could be made to flow through our streets by means of steam or water power, and very few of which can be made to flow into the city by gravity, the comparative expense of these different modes of introducing the required supply of water becomes to our citizens a very interesting and pertinent inquiry.

Whenever the source from which a community can be adequately supplied, is sufficiently elevated and near to the district requiring the service, such conduit as will permit the water to flow into the Distributing Reservoir by the force of its own gravity, being simple and economical, and least of all modes liable to casualities or failure, is doubtless preferable to all other modes. Even when the source is more distant, and the cost of the additional length of conduit required would amount to a sum whose interest would pay the expense of a supply by pumping, the regularity and greater certainty of the supply by gravity, should give to this mode the preference.

Whenever a resort to pumping becomes necessary, water power if available, is the most economical agent.

In the Tabular Statement already referred to, the comparative original cost of the works from which returns have been obtained, and also the annual receipts and expenses in each case, are given with a view to exhibit the merits of the different systems of Water Works already constructed in this country, and the compartive economy of obtaining supplies by either steam power, water power, or gravity.

In a subsequent part of this Report some statements are given showing the comparative cost of Water supplies, when obtained by either of the modes referred to.

Quantity of Water Required.

In the early history of the efforts in this country to obtain water supplies for cities, 25 to 30 gallons per day for each person of the district to be supplied, was considered an ample rate to meet all the demands whatever for water. But more recently the experience of some of our principal cities, indicates the wisdom and necessity of providing for a higher rate of consumption. During the last year, the distribution from the Water Works in Boston, was at the rate of 72 gallons per day; from the Croton Works stated to be 70 gallons, and at Philadelphia from all the works, it was at the rate of over 50 gallons per person, of the entire population of those places. In the foregoing Tabular Statement, the rate of consumption in other cities is given.

Although 40 gallons per day, for each person in a population of 50,000, would perhaps be considered a reasonable allowance for this city, at the present time, yet it would be unwise to construct a system of works at great expense, to be dependent upon a source which could not furnish, if it should hereafter be needed, at least as much as 60 gallons per day, each, for a population of 100,000. The rate first above named would give 2,000,000 gallons, and the last 6,000,000 per day, for the city.

Distributing Reservoir.

A Reservoir of a capacity sufficient to contain a supply of water for several days, and situated at an elevation which will carry the water by the force of gravity alone, to every part of the district to be supplied, is now considered indispensible to the successful operation of a system of Water Works. The substitutes for this mode of distribution, which have been resorted to in a few instances, are two; a distribution from a stand pipe, and a distribution from the pumping or supply main. Both plans are very objectionable, as they subject the service of water to the citizens, to all the casualities and irregularities of the pumping machinery; and probably in all cases increase the expense of pumping the requisite supply. At the 24th Ward works in Philadelphia, the supply costs more than three times as much per 1,000,000 gallons as that from the Schuylkill works, where there is a liberal extent of Distributing Reservoir. Doubtless this excess of cost is attributable in part to the greater elevation of the district to be supplied by the 24th Ward Works. Both these plans are also found in practice to be objectionable, on account of the quality of the water when served directly to the water takers from the pipes, without previous exposure in open space, to the atmosphere.

Whenever a Distributing Reservoir is so small that it will not contain more than one day's demand, as is the case at Cincinnati, the benefits of circulation and exposure in the air and sun, after passing through the pumping or supply main are lost. It is also claimed that too great extent in a Distributing Reservoir is a fault, since the daily supply must be drawn from a body of water which has lain for weeks in a quiescent state. The just medium in the size of such Reservoir would be that which would supply the district dependent upon it during the time required for any necessary repairs of machinery or conduits, and which, together with a Receiving Reservoir near at hand, will contain a supply for two or three weeks.

For whatever purpose a Reservoir may be designed, it should have a depth sufficient to prevent the growth of aquatic plants and also to avoid the the influence of elevated temperature upon organic matter at the bottom of the Reservoir.

Along the range of hills east of Mount Hope Cemetery, several sites may be found for the economical construction of a Distributing Reservoir. A water surface of about 3 acres, and a capacity of 30,000,000 gallons may be obtained here without difficulty, and any additional extent of Reservoir auxiliary to this, may be located about 4 miles further south. For the purpose of accurately comparing the several plans which will be described in detail, in a subsequent part of this Report, the summit of the ridge directly east of South Avenue has been assumed as a suitable site for such Reservoir.

Sources of Supply for Rochester.

Among the sources from which this city may be abundantly supplied with water, and which have from time to time been proposed to be used for that purpose, the most prominent and important ones are:

The Genesee River.

Lake Ontario.

Irondequoit Creek.

Black Creek.

Little Black Creek, or the Basin in which it rises.

Caledonia Spring.

The Mendon Ponds.

Honeoye Outlet, at West Rush.

Do. do. do. Smithtown.

Conesus Lake.

Hemlock Lake.

Of these bodies and streams of water, the most obvious and important characteristics may be stated as follows:

The Genesee River, which flows through the centre of the city, with a volume of water, one-fiftieth part of which at lowest water, would be more than sufficient to supply the city, would furnish the most simple and cheap mode of meeting this great want of our population, were it not objectionable on account of the quality of the water. Besides its proverbial hardness, the water of this river is frequently rendered turbid and unfit for use, by the effects of floods in the River. At such times the fine mould from the alluvial formation of the valley above, is borne along, mechanically suspended in such quantities, that it does not wholly subside until the waters of the river are intimately mingled with those of Lake Ontario.

By means of subsiding or filtering Reservoirs, this impurity might probably be removed. The quality termed hardness, is principally owing to the presence of lime too intimately combined to be separated by filtration, and is derived princially from the tributaries which flow into the River upon the west side, below Mount Morris, and although not invariable in its proportion to the whole quantity of water in the River, it is a serious objection to the use of this, as a source of supply for Rochester, unless Reservoirs were to be constructed of such capacity, that resort to the River itself could be dispensed with, except at times of high water. When the volume of the River is increased many fold by recent rains, the amount of lime-bearing water, in the whole quantity, remains almost invariable, and thereby the degree of hardness is greatly diminished. There can be little doubt that the water of this river may be rendered as good as that which is now supplied to many cities in this country, and much better than that which is furnished to several cities of Europe. The unoccupied water power at the Rapids affords a convenient and economical means of elevating the water to the proposed Distributing Reservoir.

Lake Ontario presents the purest and most copious supply of water in the vicinity of Rochester. The distance of this Lake from any suitable site for a Distributing Reservoir, and the elevation to which the water must be raised by either steam or water power, although very serious objections to this plan of supplying the city, would not be deemed insurmountable, if the water of the Lake could at all times be obtained in the purity which it presents at a distance from the shore, and out of the range of admixture with the waters of the Genesee River. A supply from this source would be subject, like that distributed to Cleveland and Chicago, and perhaps in somewhat less degree, to Buffalo and Detroit,to become turbid and unpleasant at the time of every storm on the Lake, and if taken from the Lake within the distance of from 1 to 3 miles from the mouth of the Genesee River, it would at times be deteriorated in quality, by the presence of the River water, which may always be traced to a considerable distance in a direction with the prevalent wind.

By either steam power to be located at the Lake shore, or water power at the Lower Falls, on the River, a sufficient quantity of water may with certainty and success, be elevated to the Distributing Reservoir, and thence conveyed through the city by gravity.

From Black Creek, in the town of Chili, at a point about 5 miles south-west of the Distributing Reservoir—from the Irondequoit Creek in Penfield, at a point where the stream in its winding course approaches within 4½ miles of the Reservoir, and from the Honeoye outlet at West Rush, about 14 miles from the Reservoir, the requisite quantity of water could, at the lowest stages in these streams, be obtained to supply the city. In each case pumping machinery would be required. For a supply from Black Creek, the most economical plan would be to conduct the water from the Creek to the Rapids in either a pipe or a conduit of brick, and from that point to elevate the supply by water power to the Reservoir. From the Irondequoit, the supply could be elevated by steam or water power, to be located near the Creek, through pipe directly to the Reservoir. From the outlet at Rush, an open channel would convey the water to the Rapids, and thence by water power it could be elevated to the Reservoir.

Near the village of Caledonia, about 19 miles from Rochester, there is found a copious and beautiful spring, discharging from 2 to 4,000,000 gallons of transparent water each day. This water might be conveyed in pipe to this city, but on account of the distance not at an elevation sufficient for its distribution by gravity.

Both the quality of the water from all the sources just named, and the cost of the works which would be required to convey the water to a suitable Distributing Reservoir, together with the continual expense of pumping are considerations which render these sources of supply for Rochester, objectionable, compared with the outlet of Hemlock Lake, at Smithtown.

In the west part of the town of Mendon are several ponds of considerable size, and of sufficient elevation for their waters to be conducted in pipe, by the force of gravity to the Distributing Reservoir—but the quantity of water flowing from them is quite insufficient to supply the city, being only about 500,000 gallons per day.

These Ponds, and the valley in which they are situated, are important only as they are located on a feasable route for pipe, or other conduit from Hemlock Lake, or its outlet to the city, and may become the site of a large Storing Reservoir for the waters of this Lake.

In a communication to the late Mayor of Rochester, the Hon. Elisha Johnson suggested Little Black Creek, or the extended Basin embracing the head waters of this Creek, together with those of the Oak Orchard, Sandy, and Black Creeks, as a source from which Rochester could be fully supplied with water. Such proportion of the annual rain fall upon this area of water shed (to which Mr. Johnson assigns an extent of 10 to 15 square miles) as could be collected in a Storing Reservoir would be much more than sufficient to supply this city with water: but the distance and the want of elevation of such Reservoir above the district to be supplied, precludes the hope that the water could be conveyed to the city, and distributed by gravity.

The plan already proposed for the introduction and elevation to the Distributing Reservoir of the waters of Black Creek, would be equally applicable to those which might be collected on Mr. Johnson's plan. The natural flow of this creek at low water, as will be seen by reference to the following table of analysis, is somewhat objectionable: yet those to be collected from the annual fall of rain and snow, would be soft and pure. Essentially upon this plan, Albany and several other places, have been recently supplied with water. The Collecting and Storing Reservoir, which is the important feature of this plan, should be constructed of such extent and depth as to avoid the unfavorable effects upon the water which at the present time seem to be justly attributed at some of the most important Water Works in the country, to vegetable growth, or to the influence of high temperature upon organic and perishable deposits in the bottom of shallow reservoirs.

From some one of the small Lakes situated south of Rochester, in the counties of Ontario and Livingston, this city may obtain an abundant supply of pure and soft water, which may be retained and stored in natural reservoirs, and from thence conveyed to the city, and distributed to its population by its own gravity. Only one question can arise as to the practicability or the expediency of this plan, and that is the one of cost. Since these Lakes possess some advantages over any other sources for a water supply to Rochester, it may be well to describe them fully.

They occupy, respectively, extended valleys, nearly parallel with that of the Genesee River, and are nearly surrounded by ranges of hills of very considerable elevation, forming around each lake an extensive water shed. Situated geologioally above the limestone formation, and being fed by springs, and by the annual rain fall over a territory whose soil is but slightly, if at all impregnated with lime, they constitute the only source from which this City can be furnished with water comparing in quality with that supplied to the cities of Boston, Brooklyn and Philadelphia.

Honeoye is the most eastern of these Lakes, and gives name to the outlet by which its own waters, together with those of Canadice and Hemlock Lakes are discharged into the Genesee River in the town of Rush.

Canadice Lake is the next in order proceeding westward, and is the smallest, and also the most elevated of the series.

Hemlock is still more westerly, the largest, and the most important one of the three, having generally bold shores and considerable depth of water. The surface of this Lake is elevated 388 feet above the Erie Canal in Rochester, and that of its outlet at Smithtown, 14 miles from the city, has an elevation of 204 feet above the Canal. Conesus is the largest and the most westerly of these lakes, discharging its waters into the river near Avon Springs, about 21 miles from Rochester.

Of all these lakes, although their waters are of nearly equal purity, the preference should doubtless be given to Hemlock, Lake, or to this lake combined with one or both of those situated east of it, for the reason that the amount of water it would furnish at the lowest stage is more than equal to that of any other lake, and is double that of Conesus Lake, while the outlet of the latter at its nearest appoach to this city, which is at Avon, is only 40 feet higher than the Erie Canal.

When the Erie Canal was completed from Brockport, to the Genesee River, and before it was finished through the mountain ridge at Lockport, the Canal Commissioners converted these lakes into reservoirs, to supply the Canal east and west of Rochester. Dams were erected across the outlets of all the lakes and their surfaces were raised about 2 feet, forming reservoirs capable of supplying the Canal for 85 days. From real or apprehended injury to the health of the residents, near the lakes, which was attributed to the overflow of the low or swampy lands, on their borders the people were induced to remove the dams, and restore the lakes to their original condition.

Again, in 1848 and 1849, the Canal authorities proposed to form reservoirs on these lakes to aid in supplying the Erie Canal east of Rochester, and surveys were made, and plans adopted for the necessary works to put the scheme into operation. The plan at this time adopted, was to draw down the lakes below the usual level, by means of deepened channels. By this plan sunken and overflowed lands would be reclaimed, and it is believed that none would object to its being carried out, provided the flow of water from the Lakes were so controlled as not to injure the Mills at the foot of the Lakes. All mills situated below these would be benefitted by the arrangement.

In this way the State proposed to draw from the 4 Lakes, 9,100 cubic feet of water per minute, for 120 days, which is equal to twice the present annual supply to the City of Boston, and equal to the whole quantity which the Croton works have for many years supplied to the City of New York.* The estimated cost of the works for Hemlock Lake was $16,000, and the quantity of water to be drawn by the plan from this Lake, was equal to 6,000,000 gallons per day, for one year.

From either Honeoye or Conesus Lake, an adequate supply of

*See Note B.

water could be obtained, but Hemlock Lake is to be preferred on account of its greater elevation, and more capacious discharge of water.

During 6 or 8 months in each year, the quantity of water flowing from this Lake is much beyond the wants of this City. By means of a dam and discharge gate, it is proposed to retain a portion of the surplus waters of the winter and spring in the Lake, until the dry period begins, and then by a draught regulated to meet the wants of Rochester, added to the amount of the usual flow in the outlet, to supply the city, without injury to the hydraulic privileges situated on the outlet.

The following Table contains an abstract of experimets made on the Chenango Canal, to determine the proportion of the falling water which could be collected into Reservoirs.

Dates.	Rain Guage. Inches.	Falling water over an area of 6,000 acres.—Cubic Ft.	Am't of water passing sluice from same source.—Cubic Feet.
Eaton Brook Valley.			
June, 1835, to June, 1836,	34.52	852,091,680	641,199,456
Madison Brook Valley.			
June, 1835, to June, 1836,	35.68	777,110,400	363,483,072

These experiments show that from 46 to 75 per cent. of the water falling annually upon any extent of water shed, may be collected into a Reservoir, or into a lake situated in the valley surrounded by a corresponding area of water shed. Similar experiments have been made in other parts of this State, at Boston, and in England, with results varying according to the locality, but all very favorable.

"The area of the drainage basin of Lake Cochituate, is given as 11,400 acres, and during the past 9 years the average rain fall upon this area has been 48 inches per annum, while the quantity of water yielded by the Lake, has, during the same time been nearly 53 per cent. of the rain fall."

west of the village at Honeoye Falls, and thence in a course quite direct, to the site of the Distributing Reservoir. The course of the second route is northerly, through the valley in which the Mendon Ponds are situated, and thence as directly as the intervening surface will permit, to the Reservoir. The third route is very direct to the Reservoir, and intermediate between the others, passing near and just east of Honeoye Falls, and of the village of East Henrietta. Of these routes, the last is the shortest one, and is preferable to the others, unless the plan of a large Storing Reservoir should be adopted.

Much of the water power formed along this outlet by the descent of 388 feet, in its course to the Genesee River, is occupied by valuable flouring mills and other hydraulic machinery, to which the use of the water of a stream, which is sometimes reduced below what is required to propel two or three runs of stone, is very important. Such mills and machinery are found at Hemlock Lake Village, at Frost's Hollow, at Factory Hollow, Smithtown, Honeoye Falls, Sibleyville, and at East and West Rush. This property has greatly declined in value within a few years, but is still of such importance that it would be inexpedient to divert the water of the Lakes, to the injury of the Mills.

All the hydraulic power on this outlet may be benefitted, or at least left uninjured by forming Reservoirs either on the outlet, or on the Lake itself, of an extent sufficient to retain from the surplus water of the winter and spring, an ample store to supply the city during the period of low water. Several sites were observed during the survey, of a favorable character for the economical construction of such a work. In the Mendon Ponds a Reservoir of 100 to 150 acres in extent could be formed, and also near, and either east or west of Honeoye Falls, favorable ground for such a Reservoir occurs; but the most natural and favorable site is found about 5 miles below the Lake, where an old meadow of 45 acres in extent is embraced within an ancient circuit of the outlet, surrounded by clayey banks, 25 feet high, except on the narrow neck across which a new channel has been cut, diverting the stream from its former course. But the cheapest and best plan for a Storing Reservoir is to form it, as has been already intimated, upon the Lake itself.

From nearly all the sources which have been described, samples of water have been obtained, and the amount of solid matter per gallon in each specimen ascertained by evaporating the water and weighing the dry residuum. The same test has been applied to the water of various wells in the city, and also from some of the most approved filters. The results are stated in the following table.

	Source or Locality.	Grains of solid matter per gallon.
1.	Lake Ontario, mouth of Genesee, w. of piers,	4.16
2.	Do. " in front of piers, ½ mile out in the Lake,	10.00
3.	Do. do. north-east of piers and beyond the stream discharged from Genesee river,	6.40
4.	Genesee River at Rapids,	11.21
5.	Do. " at high water, April, 1860,	6.40
6.	Do. " at low water, June, 1860,	9.60
7.	Do. " at high water, August, 1860,	7.46
8.	Do. " at a higher stage of water subsequent to the above, August, 1860,	5.60
9.	Do. " high water subsiding,	4.53
10.	Irondequoit Creek, Penfield,	24.68
11.	Black Creek, Chili,	72.80
12.	Little Black Creek, Chili,	9.40
13.	Tonawonda Creek, Batavia,	12.57
14.	Caledonia Spring,	44.80
15.	Mendon Ponds,	8.00
16.	Honeoye outlet, West Rush,	6.13
17.	Do. do. Smithtown, (1853,) taken at a moderate rise of water,	4.31
18.	Do. do. at low water,	2.40
19.	Honeoye Lake,	4.00

20.	Hemlock Lake,	1.33
21.	Erie Canal at Rochester, July, 1860,	8.00
22.	Acid spring, ½ mile west of Rochester,	19.20
23.	Well, North Fitzhugh Street,	26.00
24.	Do. South " "	16.74
25.	Do. North Washington Street,	34.11
26.	Do. Third Ward Tavern, Cornhill,	41.00
27.	Do. East Avenue, near Gibbs Street,	32.16
28.	Do. South Avenue,	20.54
29.	Average of Wells in Rochester,	28.33
30.	Cistern Water, soon after rain,	6.40
31.	Rain water taken in an open vessel,	1.00
32.	Filtered rain water,	14.10
33.	" " " second sample,	6.40
34.	Rain water from a cistern,	2.16
35.	Do. " from same cistern filtered,	4.33
36.	Filtered rain water,	1.92
37.	Do. " "	8.97
38.	Black Creek, second sample,	74.00

Storing and Subsiding Reservoirs.

In either of the plans which propose to elevate water to the Distributing Reservoir by a stationary power at the Rapids, an extensive Storing and Subsiding Reservoir is an essential feature. If taken during the time of low water, both the water of the Genesee River and of Little Black Creek are objectionable. But should the water of the River be taken at the time of a rise, or if taken from a retiring flood tide, it is better than that of the Croton or Schuylkill; moreover, water collected essentially on the plan proposed by Mr. Johnson from the water shed of Little Black and other creeks, would, without doubt, be found to be equally pure. For the River plan, subsiding and filtering would be requisite, and for both plans an extent of reservoir sufficient to supply the city for 100 days would be required.

It is admitted that the history of such reservoirs has been for the last few years rather unfavorable to such a project, but it is believed that the difficulties encountered at Boston, New York, Albany, New Britain and Cincinnati, are capable of satisfactory explanation, and can be remedied. It is shown by the reports of these various Water Boards and Companies, that in every instance where complaint has been made of the quality of the water drawn from such Reservoirs, that the effect may be traced to the presence of perishable matter in the bottom of Reservoirs or Ponds, or to the production in shallow water and sunken meadows, of minute vegetable organisms, and to the fermentation of living, vegetable products recently immersed in water. From the opinions of Professors Horsford, Silliman, Torry, Chilton and Craselli, these effects are not considered to be lasting, or to im-impart any unwholesome quality to the water, and it is to be inferred from their reports, that these unpleasant effects would be avoided by forming reservoirs of greater depth and with their inner surfaces wholly free from vegetable deposits and perishable matter.

Extensive storage of water is an important element in the means of supplying some of our largest cities. The daily supply of New York is greater than the minimum flow of the Croton, and will soon be greater than the medium flow, and the annual consumption of Boston is steadily approximating to the total capacity of its Lake and Reservoirs.

The daily supply, the storage, and the ratio of the storage and supply of some of the leading systems, are given in the following table.

LOCALITIES.	Daily Supply.	Capacity of Reservoir.	Number of days supply
Philadelphia, - -	19,638,442	66,000,000	3⅓
New York, - - - -	30,000,000	770,000,000	26
Boston, - - - -	15,000,000	106,000,000	7
Do. with the Lake,	15,000,000	798,000,000	53
Brooklyn, - - - -	10,000,000	240,000,000	24
Jersey City, - - -	2,000,000	55,334,000	27
Cincinnati, - - - -	4,618,587	5,000,000	1+
Albany, - - - -	2,500,000	230,000,000	92
Hartford, - - - -	785,000	8,000,000	10
Bridgeport, - - -	400,000	200,000,000	365+
New Britain, - - -	360,000	400,000,000	365+

Conductors of Water.

Aqueducts of masonry were the earliest artificial conductors of water for the supply of towns and cities. These were often constructed at great expense, forming a channel of a uniform declivity, for a considerable volume of water over intervening elevations and valleys. In crossing valleys, the earliest method was to support the high structures upon arches. At a later period pipes of lead, in the form of an inverted syphon, were used to conduct the water across the valley, from the end of the aqueduct on the one side, to the continuation of it on the other. Pipes of lead, and of earthen or stone ware, were used to convey and distribute the water from the aqueduct, and at a later period pipes of wood were extensively used for the same purpose, both in Europe and in this country. Cast iron was substituted for wood and laid in London, in 1810, and in Philadelphia in 1820. Since that time cast iron for street mains of all sizes has come into very general use. Street pipe for the conveyance of water has been made of stone, and recently of glass, and of hydraulic cement.

Pipes of wood are still in use in Springfield, Ct., and in Detroit. At the latter place, about 9,000 feet of this kind was laid during the last season.

Within the last 12 or 15 years, a water pipe formed of sheet iron and hydraulic cement, has come into use. During the present season, the manufacture of a water pipe has been commenced, which is formed of a hollow cylinder of wood strengthened by bands of iron, and protected by a coating of hydraulic cement. Only three kinds of pipe will be introduced into the following estimates, and since each kind has been claimed by its advocates or opponents to have characteristic merits or defects, a brief description of them may be desirable. It is obvious that pipe may be made of cast iron, of any desired strength, and it may be made more readily perhaps, than other materials, to assume any required form and dimensions; but since this material has no certain and uniform modulus of strength, it becomes necessary to give to the castings an extra thickness, to compensate for the deficiency.

After all the precautions of remelting the iron, and casting the segments of pipe in vertical moulds, this pipe is often found to be defective, and should never be laid without being subjected to the test of a pressure of 300 pounds to the square inch, which will generally disclose its defects. Although it can be made of such thickness as to resist any uniform pressure, yet when subjected to irregular pressure, or rapid concussion, it often bursts. But the most serious objection, perhaps, to cast iron water pipe is the "tendency to the absorption of the iron, and the gradual formation of concretions or tubercles in the interior of the pipes, by which their capacity is diminished, and the flow of water impeded.

E. S. Chesbrough, Esq., the City Engineer of Boston, in his report to the Cochituate Water Board, in 1852, remarks, that—

"The rapidity with which the interior surfaces of some of the pipes have become covered with *tubercles* or rust, has excited a great deal of interest, and has been the subject of much observation; but the cause of such a wide difference in the growth of these tubercles in different pipes, and in different places, does not appear to be clearly understood. All the large pipes that have been opened, have been partially or entirely covered on their inner surfaces, some with detached tubercles, varying from a half to two and a half inches base, with a depth or thickness in the middle, of from one quarter to three quarters of an inch; and some entirely, to an average depth of half an inch, with a rough coating, as if the bases of the tubercles had crowded together. The smaller pipes all exhibit some action of this kind, but generally to a less extent, as regards thickness, than the larger ones.

In one case, however, a four-inch pipe was found covered to a thickness of about one inch. This was in that part of Myrtle street, which was formerly called Zone street, where the entrance to a service pipe was entirely stopped by rust. Wrought-iron pipes fill much more rapidly than cast-iron ones; and in several instances, service pipes made of that metal have, during the last year, become so obstructed as to be almost or quite useless.

"The Jamaica Aqueduct pipe, which was originally 10 inches in diameter, has been, in some cases, reduced to 8, by tubercles, which however, are different in form from those in the Cochituate pipes, They appear to lap over each other in the direction of the current; this is very strikingly the case at the commencement of the pipe, as if their form was owing in some measure to the mechanical action of the current.

The following extracts are taken from the annual report of the "Cochituate Water Board to the City of Boston," for 1852, to show the growing importance of this subject:

"Among the variety of topics noticed in the report of the Engineer, which are well deserving the consideration of the City Council, there is one, in particular, to which we would now call its attention, which we consider to be eminently so. We allude to the effects which are found to be produced on the inner surface of all the iron mains and pipes, by the action of the water. The attention of the Water Board was attracted to the subject, soon after its appointment; for although the pipes had then been in use less than three years, those effects are already quite obvious and striking, and in fact had been noticed some time previous. They have since then been carefully watched, and the valuable assistance of Professor Horsford has been engaged for the purpose of ascertaining as far as is practicable, their origin, their probable progress for the future, and the means which might be relied upon, for the purpose of preventing, arresting, or retarding them, and thus obviating the consequences which were likely to be the result. The two communications of Professor Horsford on the subject, which we beg leave to annex to this report, have described with so much minuteness and clearness the present appearance and state of the interior of the mains and pipes, as does also the report of the City Engineer, that it is rendered entirely unnecessary for the Board to repeat the description, and they would therefore refer the Council to these communications. It is presumed, also, that the members of the Council are generally acquainted with those facts.

"The effects to which we now allude, are the peculiar changes which have been produced on the iron itself; and they consist in:

"1. The absorption of the iron in certain places, and the formation in its stead of a substance resembling plumbago.

"2. The gradual development of local accretions or tubercles, in the interior of the pipes, by which the flow of water is impeded, and their capacity diminished, so that the object for which they were laid becomes imperfectly accomplished, and an apprehension is excited that they may be so far closed up as to be useless hereafter.

The Water Board have heretofore thought that it would be interesting and useful to lay before the Council somewhat in detail, not only the present condition of the pipes belonging to the Water Works of this city, in relation to the subject, but also the result of such inquiries as they have been able to make into the extent of the same evils in other places, and the efforts which have been made to ascertain their nature and origin, and to provide a remedy for them, and the success of those efforts.

"The first notice taken of this subject which we have seen, appears in the transactions of the French Academy of Sciences, for the year 1836. (*Comptes Rendus, v.* 3, *p.* 131.) It is a note by *Mr. Vicat on the subject of a coating to prevent the develop-*

by *Mr. Vicat on the subject of a coating to prevent the development of tuberculous accretions in cast-iron pipes for conducting water.* He states that a report printed at Grenoble, November 22, 1833, by order of the Municipal Council, called the attention of the public to the rapid, as well as unforeseen, filling up of the large cast-iron main, of the *Chateau d' Eau*, in that town. The formation of numerous tubercles of hydroxide of iron, began to show itself shortly after the water was let on, by a perceptible though slight diminution of the discharge. The development of the accretions, however, as was proved by many accurate measurements, soon increased so much, that the supply of the *Chateau*, which had been in 1826 about 1,400 litres (about 370 wine gallons) a minute, was gradually reduced in 1833, to 720 litres (about 190 wine gallons,) showing a loss of nearly one-half."

"In 1837 the subject attracted the attention of the *British Association of Science;* and under its auspices a very elaborate investigation of the action of air and water, whether fresh or salt, clear or foul, and at various temperatures, upon cast iron, wrought iron, and steel, was made by Mr. Robert Mallet. Mr. Mallet commenced in 1838, and continued until the year 1843, a very complete course of experiments on the subject."

"The Board can merely state some of the general laws, regulating the action of fresh water on iron pipes, which Mr. Mallet considers as previously known, or established or confirmed by his experiments.

He found that *any part of iron, cast or wrought, corrodes when exposed to the action of water holding air in combination,* in one or other or some combination of the following forms, viz: 1. *Uniformly*, or when the whole surface of the iron is covered uniformly with a coat of rust, requiring to be scraped off, and leaving a smooth red surface after it. 2. *Uniformly with plum-*

bago, where the surface, as before uniformly corroded, is found in some places covered with *plumbagenous* matter, leaving a *piebald* surface of red and black after it. 3. *Locally*, or only rusted in some places, and free from rust in others. *Locally pitted*, where the surface is left as in the last case, but the metal is found unequally removed to a greater or less depth. 5. *Tubercular*, when the whole of the rust which has taken place at *every point* of the specimen, has been transferred to one or more particular points of its surface, and has there formed large projecting tubercles, leaving the rest bare."

"The size, and perhaps the form, of iron casting, forms one element in the rate of its corrosion in water. Because the thinner castings having cooled much faster and more irregularly than the thicker, are much less homogenous, and contain veins and patches harder than the rest of their substance: hence the formation of voltaic couples and accelerated corrosion.

"*He estimates that from three-tenths to four-tenths of an inch in depth, of cast iron one inch thick, and about six-tenths of an inch of wrought iron, will be destroyed in a century, in clear water.*"

"The subsequent experiments throw no new light on the cause and nature of this singular phenomenon. They show, however, that the same effect is produced by the action of air and fresh water; and this is too well corroborated by our own experience."

"The important problem of preventing the corrosive action of the water, by coating the interior surface of the pipe, was a principal object of Mr. Mallet's experiments."

"The various results of Mr. Mallet's experiments are exhibited in a full series of tables, which present to the engineer, as he thinks, 'sufficient data to enable him to predict the term of durability, and allow for the loss by corrosion of iron in all conditions, when entering into his structures.'

The last information to which we shall refer on this subject, is contained in a paper on Tubercles in Iron Pipes, by M. Gaudin, Engineer of Bridges and Roads, published in the Annales des Ponts et Chaussees, for November and December, 1851. He states that the iron conduit at Cherbourg, constructed between the years 1836 and 1838, of white casting, nearly 1¼ miles long, had become everywhere coated with tubercles, which in some places had an elevation of from 1,575 to 1,968 inches, so that the orifice of the pipe, which was when laid, about 7 inches in diameter, had been reduced to less than one-third its original section. The consequence of the diminution of the orifice, joined to the enormous loss of head occasioned by the additional friction, had deprived many of the work-shops at the end of the conduit of a supply, prevented the simultaneous playing of the fountains, and made the supply of the grand reservoir impossible, or very feeble.

"The tubercles were very broad at their base, and very strongly adhering to the surface of the pipe, and could not be removed, except by heating the pipe to a red heat, or by a forcible action of an instrument. They were of a greenish brown color, and testaceous structure, and on exposure to the air, assumed the color of yellow ocher, a sure sign of the oxydation of part of the iron which entered into their composition. Their density was almost 3,362. A chemical analysis gave the following results:

"He considered it certain, that the iron in the tubercles was to be attributed, exclusively, to an alteration which had taken place in the pipes themselves, no matter what the casting might be, whether white or gray.

"In reference to the obtaining some remedy for the evil, he observes, that waters the most pure and most proper for the ordinary necessities of life, afford no exemption, since it appears invariable, that the tubercles are in an especial manner developed by the presence of very small quantities of sea salt, which almost all waters contain. And that chemists and engineers have therefore recommended the forcing of linseed oil by great pressure into the metal, and also coatings of mortars and hydraulic cements and bituminous coverings."

"Undoubtedly the most important change which takes place on the inner surface of the pipes, as far as relates to any immediate results, is the production of the accretions. The formation of plumbago or something like it, in the place of the iron which has been absorbed, does not, indeed, protect the metal beneath it, and the action continues, perhaps even with a slightly accelerated force ; but, according to the French and English authorities, its progress is so slow that many years must elapse before any serious consequences from it alone, would be likely to happen. It is probable that the only way to prevent this action, will be found in coating the surface with some composition which will shield it."

"But with regard to the accretions, their growth has been more rapid and important, so much so that our 36 inch and 30 inch mains have become already, in consequence of the actual diminution of their area, and also of the additional friction which has been occasioned, scarcely superior in capacity, to those of 34 and 28 inches, having a clean surface; and we have had sufficient experience on the subject to convince us of the impolicy of making use of wrought iron service pipes at all, or of cast-iron ones of less than 4 inches in diameter."

"CAMBRIDGE, Jan. 14, 1852.

"THOS. WETMORE, ESQ.

"*President of the Cochituate Water Board.*

"DEAR SIR,—In reply to your favor of the 5th instant, in relation to the accretions in the Cochituate iron mains, I have to regret that my investigations thus far have thrown but little light upon the question of most importance, to wit; How far will these accretions extend?

"A brief statement of the present condition of the pipes will show the bearing of this inquiry.

"At the two points near Dover street, where one of the main iron pipes was taken up for repairs in the last autumn, there were found upon the interior surface of the pipe, nodules varying from half an inch to three inches in diameter, at the base, and having a height of from one quarter to a little more than half an inch. Some of them were of a reddish, others of a dirty yellow color, and those of each color invariably in a group by themselves. They presented concentric structure within, and rested in many cases upon slightly elevated portions of the surface of the pipe. These elevated portions were co-extensive with the inferior surface of the nodules, were of a dark brown color, and crumbled at once to powder upon being scratched with a knife.

"Portions of the surface of some sections of pipe were quite free from accretions. In some areas, the accretions were all small; in others most were large. There seemed to be no tendency among them to gather upon the bottom rather than upon the top and sides. * * * * *

"The suggestion that the accretions might be due to the growth of some kind of vegetation in which were lodged particles of the ochreous matter in suspension, in small quantity, in the Cochituate water, and which gives to it its occasional faint wine color, which is found on the bottom of the tunnel, and which accumulates in the filters—was not sustained by microscopic examination. * * * * * *

"There are reasons for believing the slight elevations of surface observed immediately beneath the accretions, to be due to changes in the texture of the iron arising from the growth of the accretion, and to an original irregularity of the casting; and further for believing that the accretions are indebted for their iron to the surface upon which they rest, and not at all, or but very slightly, to the water which flows over them.

"I have wrought-iron pipes of 1½ inches caliber, which are coated with accretions interiorly, and which in 12 months have been eaten through, from within outward, by the circulation of cold Cochituate water. I have others of the same diameter, which in 3 months have been eaten through by the circulation of hot Cochituate water.

"I have another pipe, 1 inch in diameter, which in 12 months was so nearly closed by accretions throughout its entire length, that it was removed because it ceased to serve water."

"The solicitude lies in two directions. In the first place, the accretions diminish the serving capacity. Taking the present average thickness of the incrustation at ⅜ of an inch, the serving capacity of a pipe 36 inches in diameter is reduced by the amount of an area 42⅜ square inches, which is equal to a cylindrical pipe 7.3 inches in diameter. If we conceive the accretion to go uniformly forward at this rate of 14⅛ square inches per annum, it would become a matter of immediate grave consideration. In the second place, the accretions are formed at the expense of the iron upon which they rest. With their increased thickness will come, at a remote period, diminished strength of the iron.

* * * * * * *

"I am, very respectfully,

Your obedient servant,

"E. N. HORSFORD."

The effect of these accretions was in one instance to diminish the discharge of the pipe 2o per cent. A pipe 956 feet long was cleared out at a cost of $138 50.

These effects have been observed in Albany, New York and Philadelphia; also in France and England. In Brooklyn, where the water supplied by the Water Works is about as pure as that of Cochituate Lake, these results are so much deprecated as to induce the Water Board to coat the pipe with a combination of coal tar and linseed oil put on at a high heat. The cost is $2 50 per ton. The water of Hemlock Lake being of about the same purity as that of Cochituate Lake, similar effects may be apprehended, if cast iron should be used here.

The water pipe formed of sheet iron and cement, is made in the following manner. Rolled iron of the guage of (No. 16 to 23,) as the proposed pressure may require, is riveted together in lengths of about eight feet—it is lined on the inside with hydraulic cement, and as it is laid in the pipe trenches, the sections are joined together by means of a slieve of the same material which overlaps the joints of the pipe, and is of a larger diameter than the pipe, admitting a lining of cement between the pipe and the slieve; when thus laid and connected in the trenches, it is covered on the outside with cement. For elbows and connections, the parts are either riveted or soldered together, and all service cocks are soldered to the street pipe. This kind of pipe can be made of any requisite thickness and strength, and is claimed to be a lasting and good conductor of water. It has been subjected to a great pressure, and when faithfully made has proved to be substantial. It is, however, very liable to be imperfect, from want of skill and fidelity in the construction. If laid in water, in wet trenches in frost, or if subjected to concussion, it is liable to fail. In a system of Water Works formed with this kind of pipe in Connecticut, many of the joints made by one individual were faulty and leaked, while all those made by another, were substantial. It has been made to stand the pressure of 240 feet head of water, and it has failed under the action of a pump, while the stream forced through it appeared to the eye to be perfectly uniform. Main pipe has been made in this way, of 16 and 20 inches diameter. This pipe has been in successful operation since 1836.

In constructing the water pipe formed of banded wood and cement, an attempt is made to combine the best properties of the different materials used in such a manner that each is to supply the deficiencies of the other. The cylinder which may be cut from different kinds of wood, forms a cleanly conductor of water, and is stiff and firm against any impulse or stress from without. By the wrought iron bands, it is obvious that any desired strength can be imparted to the pipe. The object of the coating of hydraulic cement is to protect the other two materials from the effects of their contact alternately with air and water. The cylinders are bored by machinery which will cut large diameters with the same facility as small ones, in sections of 8 feet in length, and joined so as to form a continued pipe by thimbles inserted into grooves cut in the ends of the sections. The bands are of rolled iron wound tightly from one end spirally to the other end, and strongly fastened at each end. To protect the bands from rust, they are coated as they are passed around the pipe, with heated coal tar.

In March last, some experiments were made at the foundry of William Kidd & Co., of this city, to ascertain the strength of pipe of this kind by the application of hydraulic pressure to the internal surface of the pipe. A piston of a diameter equal to one square inch fitted to an orifice in the iron pipe, which connected the pump with the pipe to be tested, and a graduated scale beam were used to measure the pressure per square inch. The size of the pipe was 10 inches interior, and 16 inches exterior diameter, and the length of the pieces 4 feet. The following table gives the amount of pressure applied, and the heighth of a vertical column of water which will produce an equal pressure.

NO. OF EXPERIMENT.	DESCRIPTION OF BANDS.			PRESSURE APPLIED.		
					WATER PRESSURE.	
	WIDTH.	THICKNESS.	DIST. APART.	LBS. PER SQUARE INCH.	PRESSURE SUSTAINED.	WOOD CHECKED.*
	Inches.	Inches.	Inches			
1	1	1-16	4	407	940	960
2	1	1-8	4	400	923	925

These trials were witnessed by many of our citizens.

During the enlargement of the Erie Canal, many structures formed of hydraulic masonry were removed; enclosed in the walls of these works and in their foundations, were found timber, plank and iron, which were unchanged in color or structure from the time they were placed in the work, a period of from 20 to 25 years. These facts suggested originally, the combination which forms the sheet iron and cement pipe, and leads to the expectation that the cement will also protect the materials of the banded wood pipe.

System of Distribution for Rochester.

In arranging a system of distributing pipe for this city, the following considerations will have a controlling influence:

That portion of the city which is the most distant from the Reservoir, is also much the lowest; a fact which will aid the supply of the distant portions, and even permit the use of smaller mains than would otherwise be required.

The population of the city extends over so much territory as to render an extensive system of pipe necessary to supply even the most densely settled streets; yet street mains will serve a

* See Note A.

sparse population, of somewhat smaller size than would be required for a more dense one.

The fourth and eighth, and parts of the third, fifth, sixth and tenth Wards, are so much higher than the other portions of the city, as to render separate mains from the Distributing Reservoir for the supply of the high and the low districts necessary. This plan has been found indispensible at Albany and Quebec, and will be expedient here.

Main pipes must be laid across the Genesee River once, and across the Canals three times to supply the whole territory requiring water.

In the schedule of street mains upon which the estimate of the system of distribution is based, the sizes of the pipes have been adjusted to give efficiency to the whole distribution, with such economy as is imperatively demanded by the great extent of the district to be supplied with water. Two mains of 12 inches diameter, are to be laid in South Avenue to the Erie Canal, and two across the River and down Plymouth Avenue. From these mains, pipes of various diameters are to extend into the different streets, to be connected at all street crossings.

The estimated cost of Distributing Pipe for the city, is given among the other estimates of cost.

Estimates of Cost.

General Outline of the different Plans proposed for supplying Rochester with Water; the daily amount being at the rate of 40 gallons for each person in a population of 50,000, and equal to 2,000,000 gallons.

1st. By the first plan, it is proposed to elevate the water of Lake Ontario, by Steam Power, located at the Lake Shore. A supply pipe, of wood, to extend 1,000 feet into the Lake, and a pumping main of cast iron, 30 inches in diameter, to extend thence to the Distributing Reservoir, east of Mount Hope Cemetery.

By a modification of this plan, the water of the Lake is to be conducted by a 36 inch main to a pump well at the lower falls, and thence elevated and forced to the Reservoir by a water pressure engine.

2d. By the second plan, the water of the Genesee River is to be raised by water or steam power at the Rapids, to a storing and subsiding Reservoir, south of Mount Hope ridge, and thence by the same power to the Distributing Reservoir.

3d. By the third plan, the rain fall upon the sources of Little Black Creek is to be collected into a Storing Reservoir in the valley towards the mouth of that Creek, and conducted thence by a 20 inch pipe to the pumping engine at the Rapids, and from that point by either water or steam power to the Distributing Reservoir.

4th. By the fourth plan, the water of the Honeoye Outlet is to be taken at Smithtown, and conducted by a 20 inch pipe directly to the Distributing Reservoir. Auxiliary to this plan there is to be either a large Storing reservoir on the route of the main pipe, or the Lake itself is to be made such Reservoir.

5th. By the fifth plan, the water of Hemlock Lake is to be conveyed in a 16 inch pipe to the Distributing Reservoir.

On all the plans except the first one, the cost of the works has been varied by introducing into the estimates the three kinds of water pipe described in a preceding part of this report, only cast iron pipe is used in Plan No. 1, and for the mains, in plan No. 2, for the reason that pipes of the largest diameters have not yet been made of the other kinds.

The estimate of an Engine House is common to the first three plans, and that of the Distributing Reservoir and Distributing Pipe, is common to all the plans.

Pump House 50 *feet square, of Brick.*

ITEMS.	Quantities.	Price.	Amounts.
Brick, and laying, ...M.	350,000	$12 00	$ 4,200
Foundation,............................perch	400	12 00	600
Excavation,..........................C yards	1,500	20	300
Paved floor...............................feet	1,600	25	400
Windows,..	24	6 00	144
Doors,..	4	20 00	80
Roof of tin,..........................squares	40	50 00	2,000
Foundation for engine,....................			1,800
			95,24
Contingencies			476
			$10,000

Storing Reservoir, 50 *acres,* 25 *feet deep, capacity,* 350,000,000 *gallons.*

ITEMS.	Quantities.	Prices.	Amounts.
Excavation and embankment, C yards	165,000	20	$33,000
Puddling earth, ...	30,000	8	2,400
Slope wall,.....................................	5,000	1 50	7,500
Gates, screens, &c............................			500
Masonry, setting pipe. gates, &c.,......	200	8 00	1,600
			45,000
And for contingencies, ...			1,600
			46,600
For feltering beds,............................			
Masonry, ...C yards	700	3 50	2,450
Clean gravel .... "	710	1 50	1,065
Cobble stone,........................... "	300	75	225
			50,340
Add for contingencies, ...			660
			51,000
Land for Reservoir			5,800
			56,800

Distributing Reservoir:—Extent 4 *acres, depth* 25 *feet, capacity* 26,000,000 *gallons.*

ITEMS.	Quantities.	Prices.	Amounts.
Excavation and embankment, ...	47,000 C yards	$ 20	$9,400
Puddled earth, ...	20,000 "	15	3,000
Slope wall,..................................	1,000 "	3 00	3,000
Masonry, ...	200 "	10 00	2,000
Brick lining,................................	600,000 "	10 00	6,000
Gates, ...	6 "	60 00	360
Setting gates, sewers, &c., ...			360
Fence, sodding, graveling,..............	1840 feet	1 00	1.840
Keeper's house,............................			1,000
Land for site, ...	5 acres	8 00	4,000
			$30,960
Add for contingencies, ...			3,040
			$34,000

Distributing Pipe, 54 *miles, Cast Iron.*

ITEMS.	Size	Extent—feet.	Prices.	Amounts.
Street Main, ...	12	25,000	$2 55	$63,750
Do. "	10	13,000	2 00	26,000
Do. "	8	42,000	1 55	65,100
Do. "	6	110,000	1 10	121,000
Do. "	4	100,400	75	75,300
Branches for hydrants,...............	8	7,000	50	3,500
				$354,650
Extra for rock excavation,...............				4,000
Do. for Canal and River crossings,				5,000
Fire hydrants, ...		400	26	10,400
Gates and stop cocks		500	25	12,500
Branches, elbow, &c.,....................				2,500
Relaying pavements,.....................				3,000
				$392,050
Add for superintendance and conting's				30,950
				$423,000

Distributing Pipe, Sheet Iron and Cement.

ITEMS.	Size; inch's	Extent; feet.	Prices.	Amounts.
Street Main, ...	12	25,000	$2 05	$51 250
" "	10	13,000	1 48	19,240
" "	8	42,000	1 21	50,820
" "	6	110,000	94	103,400
" "	4	100,400	61	61,244
Branches for hydrants, ...	3	7,000	48	3,360
				$289,314
Extra for rock excavation				4,000
Do. Canal and River crossings,				5,000
Fire hydrants, ...		400	26 00	10,400
Gates and stop cocks, ...		500	25 00	12 500
Branches, elbows, &c.				2,500
Relaying pavements, ...				3,000
				326,714
Add for super'ce and contingenc's				26,286
				$353.000

Distributing Pipe banded Wood and Cement.

ITEMS.	Size: inche	Extent: feet	Prices	Amounts.
Street main, ...	12	25,000	$ 1 17	$ 29,250
Do. do.	10	13,000	1 00	13.000
Do. do.	8	42,000	81	34,020
Do. do.	6	110,000	65	71,500
Do. do.	4	100,400	45	45,180
Branches for hydrants, ...	3	7,000	36	2,520
				$195,470
Extra for rock excavation, ...				4.000
" canal and river crossings				5,000
Fire hydrants, ...		400	26	10,400
Gates, stop cocks, &c.		500	25	12,500
Branches, elbows, &c.				2,500
Relaying pavements, ...				3,000
				232,870
Add for super'ce contingenc's				12,130
				$256,000

PLAN NUMBER ONE.

FROM LAKE ONTARIO, BY STEAM POWER AT THE LAKE—DAILY SUPPLY 2,000,000 GALLONS.

		PRICES.	AMOUNTS.
Two steam engines,	each	$40,000	$80,000
Engine house and foundation,			10,000
Supply pipe of wood,	1000 feet,	$8,00	8,000
Pier in Lake and pump well,			6,000
Rising main, 4 miles, 30 inch,		$11,50	242,880
" " " "		9,50	200,640
			547,520
Distributing Reservoir,			34,000
Distributing pipe, 54 miles, C. I.,			423,000
			$1,004,520
Add for superintendence, contingencies, and right of way,			25,480
			$1,030,000

FROM THE LAKE, BY WATER POWER AT CARTHAGE.

Supply main from Lake, 6 miles, 36 in.,		$15,00	$475,200
Engine house, foundations, &c.,			10,000
Pump-well, pier in Lake, &c.,			6,000
Two water-pressure engines,	each	$30,000	60,000
Water power,			15,000
Rising main, 2½ miles, 30 in.,		$10,00	132,000
Supply pipe in Lake, of wood,	1000 feet,	8,00	8,000
			$706,200
Distributing Reservoir,			34,000
Distributing pipe, C. I.,			423,000
			$1,163,200
Add for superintendence, contingencies and right of way,			15,800
			$1,179,000

PLAN NUMBER TWO.

GENESEE RIVER, BY WATER POWER AT THE RAPIDS.

	PRICES.	AMOUNTS.
Dam, race and forebay,		$ 9,500
Two central discharge wheels and pumps, each	$35,000	70,000
Pump house and foundations,		8,000
Rising main, 1½ miles, 20 in.,	6,50	51,480
Water power,		10,000
Right of way,		1,000
		$149,980
Storing and Filtering Reservoir,		56.800
Distributing Reservoir,		34,000
Distributing pipe, C. I.,		423,000
		$663,780
Add for superintendence and contingencies,		16,220
		$680,000

FROM THE RIVER, BY STEAM POWER.

Dam, race and forebay,		$ 9,500
Pump house and foundations,		8,000
Two steam engines and pumps, each	$30,000,00	60,000
Rising main, 1½ miles, 20 in.,	6,50	51,480
Right of way,		1,000
		$129,980
Reservoir and distribution,		513,800
		$643,780
Superintendence and contingencies,		16,220
		$660,000

SAME, WITH DISTRIBUTING PIPE OF IRON AND CEMENT.

Dam, engines. mains, &c.,	129,980
Reservoirs,	90,800
Distribution,	353,000
	$573,780
Superintendence and contingencies,	10,220
	$584,000

SAME, WITH DISTRIBUTING PIPE OF BANDED WOOD AND CEMANT.

Dam, engines, mains and reservoirs,	$220,780
Distribution,	256,000
	$476,780
Superintendence and contingencies,	8,220
	$485,000

PLAN NUMBER THREE.

LITTLE BLACK CREEK AND BASIN, BY STEAM OR WATER POWER AT RAPIDS.

	PRICES.	AMOUNT.
Dam, race, engines, mains, &c.,		$149,980
Storing reservoir in Chili,		46,600
Land for reservoir,		5,000
Dam and supply pipe, 20 in., ...3,600 feet,		20,000
Main from reservoir to pump, 4 miles, 20 in.,	$5,50	116,160
Right of way,		800
		$338,540
Distributing reservoir,		34,000
Distributing pipe,		428,000
		$795,540
Add for superintendence and contingencies,		14,460
		$810,000

SAME, WITH PIPE OF IRON AND CEMENT.

Dams, reservoirs, engines, &c.,		$372,540
Distribution, of sheet iron and cement,		353,000
		$725,540
Add for superintendence and contingencies,		13,460
		$739,000

SAME, WITH PIPE OF BANDED WOOD AND CEMENT.

Dam, reservoirs, engines, &c.,		$372,540
Distribution, of banded wood, &c.,		256,000
		$628,540
Add for superintendence and contingencies,		11,460
		$640,000

SAME PLAN, WITH MAINS ALL OF BANDED WOOD AND CEMENT.

Dams, race and engines,		$98,500
Rising main, 1½ miles, banded wood and cement, 2, 14 in.,	$1,40	22,176
Reservoirs,		90,800
Land for reservoir,		5,000
Supply pipe, banded wood and cement, 3600 feet, 2, 14 in.,	$1,40	10,080
Distribution,		256,000
Main from reservoir to pump, 4 miles,	$2,80	59,136
		$541,692
Add for contingencies,		10,308
		$552,000

PLAN NUMBER FOUR.

HONEOYE OUTLET, AT SMITHTOWN, BY GRAVITY, MAIN PIPE 20 INCHES, SUPPLY 2,000,000 GALLONS—MAIN OF CAST IRON.

	PRICES.	AMOUNT.
Dam, bulkhead and screens, Smithtown,................		$ 5,000
Dam and pier at Lake, and deepening channel,.......		20,000
Main pipe, 14 miles, 20 inch,............................at	$6,50	480,480
		505,480
Distributing reservoir,....................................		34,000
Distributing pipe,..		423,000
		$962.480
Add for superintendence and contingencies,...........		17,520
		$980,000

SAME PLAN, WITH DISTRIBUTION OF IRON AND CEMENT.

Dams, pier and main, as above,..........................		$505,480
Distributing reservoir,......................................		34,000
Distribution, of iron and cement pipe,.................		353,000
		$892,480
Add for superintendence and contingencies, ...		14,520
		$907,000

SAME PLAN, WITH DISTRIBUTING PIPE OF BANDED WOOD AND CEMENT.

Dam, pier, reservoir, &c., as above,.....................		$ 59,000
Main pipe of cast iron, "		480,480
Distribution, banded wood and cement,...............		256,000
		$795.480
Add for superintendence and contingencies,.........		8,520
		$804,000

SAME PLAN, WITH PIPE WHOLLY OF BANDED WOOD AND CEMENT.

Dam, pier, reservoir, &c., as above,.....................		$59,000
Main pipe of banded wood and cement, 14 miles, 2, 14 in.,..	$1.40	206,976
Distribution, banded wood and cement, ...		256,000
		$511,976
Add for superintendence and contingencies, ...		8,024
		$530,000

PLAN NUMBER FIVE.

SUPPLY FROM HEMLOCK LAKE, BY GRAVITY, PIPE 16 INCH, 2,000,000 GALLONS.

	PRICES.	AMOUNT.
Dam, pier and deepening channel,........................		$ 20,000
Main pipe, 14 miles, 16 in.,................................	$5,00	369,600
" " "	4,75	351,120
		$740,720
Distributing reservoir, ...		34,000
Distributing pipe,...		413,000
		$1,187,720
Add for superintendence and contingencies, ...		22,280
		$1,210,000

SAME PLAN, WITH PIPE OF S. IRON AND CEMENT.

Dam, pier, and deepening channel,......................		$ 20,000
Main pipe, 14 miles, 16 in., ...	$3,50	258,720
" " "	3,20	236,544
		$515,264
Distributing reservoir,.......................................		34,000
Distributing pipe, ...		353,000
		$902,264
Add for superintendence and contingencies,..........		8,736
		$911,000

SAME PLAN, WITH PIPE OF BANDED WOOD AND CEMENT.

Dam, pier, and deepening channel, ...		$ 20,000
Main pipe, 14 miles, 16 in.,...............................	$2,00	147,840
" " "	1,60	118,272
		$286,112
Distributing reservoir,.......................................		34,000
Distributing pipe,..		256,000
		$576,112
Add for superintendence and contingencies, ...		5,888
		$582,000

Cost of Pumping Water Supplies.

LOCALITIES.	Daily Supply.	Annual Expense	Cost per mill'n g.
Philadelphia, aggregate,	19,638,442 g.	$50,184	$ 7 01
Fairmount, separately,	9,288,415	5,803	1 71
Twenty-Fourth Ward Works, separately, ...	727,277	7,762	29 23
Schuylkill, " " ...	7,248,114	25,104	9 49
Delaware, " " ...	2,379,685	11,515	13 26
Pittsburgh,	4,075,755	26,000	17 47
Hartford,	785,338	5,000	17 44
Jersey City,	2,000,000	10,000	13 69
Buffalo,	3,000,000	19,000	17 35
Cleveland,	1,000,000	7,712	21 13
Detroit,	2,142,774	15,749	21 37
Chicago	3,000,000	25,011	22 88
Cincinnati	4,618,567	28,000	16 61
Cambridge,	400,000	3,500	23 97
Aggregate,	30,645,183	$176,591	

$176,591÷30,645,183=5,762.

Average annual expense of 1,000,000 gallons daily, $5,762.

" daily " " " $15 78.

The Fairmount Works are not included in the above aggregate, because they use water power, and the Twenty-Fourth Ward Works are omitted because they are very unlike the other works included in the statement. The Fairmount Works are the only ones using water power from which complete returns have been received, and they exhibit a very favorable result as to the cost of pumping by water power.

Although the cost of pumping water at the Schuylkill Works is the lowest, yet it may be more safe to take the average cost of pumping at all the works which use steam power, as an index of the expense of a supply of water for this city, on plans No.'s 1, 2 and 3; viz: for 1,000,000 gallons daily $15,78; and for 2,000,000 gallons $31,50.

Summary of Estimates.

DIFFERENT PLANS.	KINDS OF WATER PIPE.		
	Cast Iron.	Cement and Iron.	anded w& cem't
Plan No. 1---*Lake Ontario.*			
Steam power..............................			
Cost of engine, pipe, &c.,.....	$1,030,000	960,000	868,000
Daily expense of pumping, $66......			
Capital at 6 per cent, equal to.........	401,500	401,500	401,500
	$1.481,500	$1,361,500	$1,264,500
Plan No, 1—*Water Power.*			
Cost of engine, pipe, &c., ...	1,179,000		
Daily expense, ...$16 50		1,109,000	1,002,000
Capital at 6 per cent, equal to........	100,375	100 375	100,375
	$1,279,375	$1,209,375	$1,102,375
Plan No. 2: *Gen. River water power.*			
Cost of engine, pipe, &c.,.............	680,000	584,000	485,000
Daily expense $15			
Capital at 6 per cent, equal to	91,250	91,250	91,250
	$771,250	$675,250	$576,250
Plan No. 2---*Steam power.*			
Cost of Engine, pipe, &c.,............	660,000	584,000	485,000
Daily expenses..................$31 50			
Capital at 6 per cent, equal to........	191,625	191,625	191,625
	851,625	775,625	676,625
Plan No. 3--*Little B. Creek, water p.*			
Cost of engine, pipe, &c..............	810,000	739,000	552,000
Daily expenses $7 50			
Capital at 6 per cent, equal to	45,625	45,625	45,625
	855,625	784,625	597,625
Plan No. 4—*Honeoye Outlet.*			
Pipes, reservoirs, &c.,..................	980,000	907,000	530,000
Plan No. 5—*Hemlock Lake.*			
Pipe, reservoirs, &c.,....................	1,210,000	911,000	582,000

An inspection of the estimates, and the above summary will show that the expense of pumping water by steam power from Lake Ontario, will equal the interest at 6 per cent on $401,500, a sum equal to the cost of a 20 inch main of cast iron, 11⅜ miles long; and that the cost of pumping by water power from the River, will equal the interest on $91,250, a sum equal to the cost of two 14 inch pipes of banded wood and cement more than 6 miles in length.

For an approximation to the income which may be anticipated from the construction of water works, some of the most experienced and competent engineers have estimated the rate of one dollar for each person of the entire population of a city, as sufficiently accurate. The following statement shows that the receipts of the four cities where the distribution is the most complete, (Boston, Albany, Jersey City, and Cincinnati,) amount to an average rate of $1 41 for each person. Embracing in the statement all the works from which full returns have been received, the rate is 94 8-10 cents, as is shown below:

Table showing the Ratio of the Income of Water Works, to the population of the various Cities supplied.

CITIES.	Population.	Receipts.	rate pr head
Philadelphia	600,000	$551,180	$ 91
New York,	934,000	800,219	85
Boston,	180,000	316,290	1 75
Albany,	66.850	80,517	1 21
Hartford,	50,000	26,000	52
Jersey City,	30,000	65,000	2 16
Buffalo,	81,541	50,000	61
Cleveland,-	43,555	13,980	32
Detroit,	70,000	57,192	81
Chicago,	115,338	102,709	89
Cincinnati,	180,000	184,837	1 02
New Orleans,	160,000	140,000	87
Plymouth.	4,500	3,700	82
Bridgeport,	10,000	7,000	70
Malone,	3,000	1,500	50
Watertown,	6,000	3,500	58
	2,534,284	2,403,624	
2,403,624÷2,534,284=948.			
Rochester,	48,096	$45,595	948

The rate of 95 cents per person, will doubtless be considered a reasonable one for this city, and with a population of 48,096, (by the late census,) the amount will be $45,691.

In Philadelphia there are two private companies, which supply portions of the city. One Ward is unsupplied, and in another Ward water is but just introduced. 600,000 is therefore probably a number quite as large as that actually supplied with water in this city.

The following estimate is based upon an enumeration recently made, of the probable water takers in this city, within the proposed district to be supplied. It is considerably below the number actually to be found within those limits, and the rates affixed to each class are also low compared with those now charged in other cities.

Classification and probable number of Water takers and Estimated Receipts.

CLASSIFICATION.	Number.	Rates.	Amounts.
Houses of first class,	150	$30	$4.500
Do. second class	1,100	15	16,500
Do. third class,	1,900	6	11,400
Do. fourth class,	1,400	4	5,600
Stores, first "	70	8	560
Do. " "	150	6	900
Stores of third class, shops, offices, Restaurants, and miscellaneous,	500	5	2,500
Hotels, first class,	6	50	300
Do. second class,	6	20	120
Do. third class inns and saloons	26	8	208
Banks,	11	7	77
Private schools	11	8	88
University,		50	50
Public Halls	5	10	50
Arcades,	2	50	100
Foundries,	7	25	175
Manufactories,	25	12	300
Steam engines,	20	15	300
Breweries,	5	30	150
Bakeries,	6	15	90
Meat markets or stalls,	40	6	240
Upper halls with offices and rooms,	10	8	80
Livery stables,	12	30	360
Private do.	70	6	420
Nurseries,	3	45	75
House of refuge,		60	60
Paper Mill,			150
Gas Works,			75
			$45.428

Most of these systems of Water Works have been constructed, and are controlled by the cities whose inhabitants they supply, and there is no charge made, and no rent received on account of the water used by the Fire Departments, or for other public purposes. Buffalo is almost the only exception. Without naming the amount which it might be expected that the city would pay for water for all public uses, should the works be constructed by a company, it may be proper to remark that should the company receive from the city and county, and also from the railroads, a compensation at the usual rate paid in other cities for such purposes, it would raise the amount of anticipated income considerably above that stated on page 64.

The foregoing estimates of income are based upon the receipts of the year 1859, while the population stated is that of the year 1860.

Any extension of the system of distributing pipe which the future growth of Rochester may require, can be laid at so cheap a rate, compared with the whole expense required to introduce and distribute water at first, that the investments in such extension will be sure to pay a favorable per centage on the required expenditure. The whole cost of supplying 54 miles of our streets with water will be something more than $10,000 per mile. After this original expenditure has been made, one mile of the extension of street mains will cost only about $3,500.

It has been claimed that hydraulic cement produced no effect on water contained in cemented cisterns, or passing through pipe lined with this material. But the experiments on water obtained from filters, given on page 36 of this Report, No.'s 30, 32, 33, 34, 35 and 37, seem to disprove this claim. These samples of water were all, except No. 30, taken from filters supposed to be in good order, and had been previously collected in cemented cisterns. The different results in the five trials, are probably due, in part, to the condition of the filters.

From these results it should perhaps be inferred that water passing through the sheet iron and cement water pipe, will be, to some extent, impregnated with lime, which is one of the constituents of the hydraulic cement which forms the lining. This kind of water pipe can be seen and examined at the Paper Mill located at the Lower Falls in this City.

Water pipe of banded wood and cement is now in course of manufacture, and is to be laid down for a system of Water Works at Elmira in this State.

Should a main pipe be laid down from this city to Smithtown, in accordance with Plan No. 4, it might hereafter, without any change, become a part of the necessary main from Rochester to Hemlock Lake, according to Plan No. 5, if our citizens should deem that plan preferable. The route for pipe or conduit is identical between the Distributing Reservoir and the outlet at Smithtown.

The construction of a permanent system of Water Works, and the introduction of an abundant supply of pure water into this City will benefit all its public and private interests, much beyond the amount of income which may be derived from water rates. So important an element of prosperity added to our present advantages of position, soil and climate, will be felt through almost all the relations of industry, enterprise and capital, increasing to some extent the value of all kinds of property. To what extent the opinions of the most judicious would vary, and there are no sure data from which a reliable estimate of the amount can be made. The amount of the assessed valuation of real and personal estate in Rochester is $11,250,157, and perhaps the real value is not less than $20,000,000. The lowest rate at which, in the judgment of the least sanguine of our citizens, this amount would be increased, would afford a very considerable proportion if not the whole amount required to construct Water Works for the City.

From sources which are deemed entirely reliable, the amount of the premiums paid in Rochester the last year for insurance, is found to be not less than $130,000, and it is believed that not more than one-half the property exposed to loss by fires, and which would be benefitted by a full supply of water, is now insured.

The difference in the rates of insurance in Boston and Charlestown, cities adjacent to each other, the one having an abundant supply of water, and the other no foreign supply, as ascertained from authentic sources, is nearly ¼ of 1 per cent. The Croton Water Board, soon after the introduction of the Croton water into the City of New York, stated the reduction in the rates of insurance in that City, to be higher than this. It is believed that the reduction of the rates in this City would be at least 15 cents on $100. Our citizens will thus save at least $19,500 in the amount of premiums paid annually for insurance, and also be benefitted by an equal amount in the protection afforded by a full supply of water and an adequate number of fire hydrants to property not now insured, making an aggregate of $39,000.

None can doubt that the construction of the systems of Water Works in New-York, Boston and Philadelphia, were wise and beneficent enterprises, which have contributed largely to the subsequent development and prosperity of those Cities.

Among the various Works which have since been constructed in other Cities, some have been completed at a higher cost relative to population and wealth than those just named, yet all would come within the range of profitable and productive investments, if to the actual income derived from consumers, there should be added the results of the indirect influence of Water Works, already alluded to.

Even when this enterprise is to be undertaken at the public expense, the amount of the expenditure should bear a reasonable proportion to the population, the business, and the aggregate wealth of the community it is designed to benefit.

The following tabular statement exhibits the character of the different systems of Water Works in the country, considered as provident investments, and the varied results show conclusively that although the direct income, together with the collateral benefits expected to result therefrom, may render it expedient in any instance to construct Water Works, yet a private Company, relying upon water rates alone for a remuneration cannot safely expend too large a capital in the first cost of works.

In many of our Cities, on account either of too great original cost, too low a tariff of water rates, or too contracted a system of distribution, there is no present prospect that the supply of water will pay even the lowest rate of interest on the cost of construction; while, in other Cities, they have been so constructed and managed that the receipts pay expenses, an interest on the total cost, and a surplus to be applied to the extension of the works.

The following table shows the relative cost of Water Works to the population, and also to the assessed valuation of real and personal estate in the various Cities supplied by them, as well as the excess or the deficiency of the annual receipts, after paying the annual expenses, and interest at 6 per cent. on the cost of the Works:

TABULAR STATEMENT.

CITIES.	*Populat'n	Valuation.	Ratio of Cost— To Populat'n	Ratio of Cost— To Valua'n	Deficiency of Income.	Excess of Income.
Philadelphia,...	600,000	$155,697,669	$ 6,50	$0.0250	$	$237,791
New-York,......	934,000	550,000,000	24,62	.0418	632,038	
Boston, ...	180,000	268,429,000	30,96	.0210	47,257	
Pittsburgh,......	100,000	10,400,000		.0700	5,000	
Brooklyn,.......	250,000	191,047,136	19,20	.0255		
Albany, ...	66,350	26,072,955	16,19	.0410		8,030
Hartford, ...	50,000	23,378,338	8,55	.0180	7,426	
Jersey City,.....	30,000	12,932,310	32,44	.0752	13,399	
Buffalo,..........	81,540	33,229,025	6,49	.0159	800	
Cleveland, ...	43,555	22,000,000	12,62	.0250	27,643	
Detroit, ...	70,000	16,214,893	11,85	.0511	8,189	
Chicago, ...	115,338	36,553,380	8,79	.0277		6,489
Cincinnati,......	180,000	91,961,978	7,55	.0147		51,964
New-Orleans,...	160,000		6,25			54,000
Troy,.............	40,000	12,853,290	5,12	.0159		4,641
Utica, ...	25,000	4,330,991	3,00	.0173		3,200
Rockland,.......	10,000	2,723,055	5,00	.0183		500
Cambridge, ...	30,000		10,00		9,500	
Plymouth, ...	4,500	3,197,300	18,22	.0256	1,720	
Bridgeport, ...	10,000	6,641,873	11,50	.0174	1,900	
Malone,..........	3,000	696,800	4,00	.0172		530
Watertown,.....	6,000		8,33		1,000	
New-Britain,...	6,000	2,000,000	8,33	.0250		

* Official returns may vary the numbers in this column.

By means of the Genesee Valley Canal, and a short line of Railroad to McKean County, in Pennsylvania, the coal of that region seems destined, at no distant day, to be furnished cheaply and in abundance to this City, and from this point to the Counties east and west of us, and to Canada.

Originally the natural emporium of the beautiful and fertile Valley of the Genesee River, the position, facilities and resources of Rochester have been gradually improved and developed by its Canals, Railroads, Lake, Harbor, and the extensive hydraulic power in its midst, and should there now be added to these advantages an ample supply of pure water, and ultimately an abundance of cheap fuel, both so important and essential to the development of steam power and many departments of mechanical enterprise, the industrial, manufacturing and commercial prosperity of our City would be advanced beyond the present anticipations of its people.

With a climate temperate and genial in summer, and not rigorous in winter, Rochester is surrounded by a country of great agricultural resources, adapted to the various productions of the farm, the vineyard, and the orchard, and although the energies of the soil may remain dormant in the embraces of winter a little later than in some southerly or westerly regions, yet the severity of a northerly latitude is tempered by the proximity of our large lakes, and the rapid opening of the floral season, with the certain and early maturity of the varied and bountiful harvest, fills the storehouse and the market-stall with a profusion, variety and excellence not surpassed in any other district of our favored land. From gentlemen who have traveled in most parts of the United States, and also in Europe, it is no uncommon remark, that they had seen no market supplied with meats, fish, vegetables, cereals and fruits of better quality and in greater variety and abundance than that of Rochester, and also that with a supply of pure water, this City would become one of the most desirable places of residence within their knowledge.

Copies of this Report will be forwarded to the officers of the Water Boards with whom correspondence has been had, and should any errors be found in the Report, in relation to the Works with which they are connected respectively, they will confer a favor by pointing them out.

In conclusion, I may be allowed to express my obligations to the gentlemen connected with the various Water Works in the country, who have so politely and promptly furnished the information solicited from them, and especially for the personal attentions received in June last, which so much facilitated the investigations in which I was engaged. Among the last, it may not be improper to mention the Mayor of Boston, the Chief Engineers of the Water Works in Boston, New York and Philadelphia, the Superintendents of Water Works at Albany, Hartford, Bridgeport, Buffalo, Jersey City and Cleveland, O., Mr. E. T. Stanley, of New Britain, the Messrs. Wells, Contractors of the Brooklyn Water Works, Beach & Woodruff, of Hartford, Ct., and Starr, of the Camden Iron Works.

DANIEL MARSH.

NOTE "A," PAGE 50.

In these experiments, the force of the pressure applied to the interior of the pipe was increased until the wooden cylinders were slightly checked, permitting a thin vein of water to pass out. The bands were not broken, nor was their ultimate strength reached.

NOTE "B," PAGES 19 AND 30.

Originally two 36-inch pipes were laid across the High Bridge, which conveyed about 30,000,000 gallons of water per day. Within a few years an additional one has been laid, and it is now proposed to lay either two more of similar size, or one of 7 feet diameter. This will doubtless convey as much water as can flow in the Aqueduct.

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